

8.7 Dr J.A.G. Williams, Department of Chemistry, University of Durham *Light-emitting platinum(II) complexes: from display screen materials to sensors*

Many organic compounds are fluorescent. Shine UV light at them or apply an electrical charge and they may emit light. So why should there be any advantage in introducing "jewellery" into the compound... in the form of a platinum metal ion? The reason is that heavy metal ions like platinum can promote switching-over of the spin of electrons. Whereas organic molecules emit light from excited states where half the electrons have the opposite spin to the other half, metal complexes emit from triplet states where the two highest-energy electrons have the same spin.

This is relevant to organic light emitting devices (OLEDs). Widely expected to be the next generation of display screen technology, OLEDs make use of small organic molecules or conjugated polymers, and offer advantages over existing LED technology; e.g. they can be formed as thin flexible plastics, so that TV screens may eventually be made by ink-jet printing. However, only a minority (25%) of the excited states that are formed when electrical charge is applied can emit light, namely the spin-paired singlet states. Luminescent heavy metal complexes are required to induce emission from the normally non-emissive triplet states, which comprise 75% of those formed. In this way, device efficiency can be greatly increased.

Our research is exploring the synthesis and applications of a new family of compounds containing platinum bound to N[^]C[^]N-coordinating ligands [1]. By N[^]C[^]N, we mean an organic molecule that coordinates to the metal through two nitrogens and a central metal-carbon bond. The objective of our research is to understand what controls the emission colour and brightness of the luminescence of these compounds.

With collaborators in Bologna, Italy, we have incorporated our compounds into prototype OLED devices, and observed high efficiency of light emission [2]. Moreover, the compounds are able to stack together like pancakes, and when they do so, the excited state of one molecule can associate with the ground state of a second one, leading to a new species – called an *excimer* – that emits red light. This has allowed us to obtain high-performance emitters in the near-infrared region, which is normally a particularly difficult part of the spectrum to get good efficiencies [3]. An exciting recent development is our discovery that by controlling the monomer-excimer ratio, we can produce desirable *white light* efficiently.

We are also investigating the application of our compounds to new sensory systems. For example, the emission is sensitive to the local concentration or partial pressure of dioxygen. In collaboration with Dr Peter Douglas and Rachel Evans at the University of Swansea, the complexes have been immobilised into thin polymer films, where they can signal changes in oxygen concentration through changes in the intensity of light emitted [4]. By using a combination of two different platinum complexes which emit different colours, and which have different sensitivities to oxygen, we obtained a simple device to indicate oxygen concentration displaying a "traffic-light" response (see figure). Such oxygen sensors could have interesting potential as simple, flexible sensors in food-packaging applications.

Dr Williams and his team in Durham are grateful to the National MS Service for providing invaluable support in the characterisation of the new compounds prepared in these studies (ref 1), and subsequently employed in the devices. These include measurements at variable ionisation voltages, which allow the parent species to be unambiguously identified, rather than just the Cl-ionised fragment ions normally detected. We also warmly thank our collaborators Drs Valeria Fattori, Massimo Cocchi, Peter Douglas and Rachel Evans.



Figure shows thin, spin-coated ethyl cellulose films of our sensor, when irradiated with ultra-violet light (366 nm), under different ambient concentrations of oxygen (from top to bottom: 0, 50-10%, 30-100% O₂) [ref 4].

Key references:

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3. M. Cocchi, D. Virgili, V. Fattori, J.A.G. Williams and J. Kalinowski, Highly efficient near-infrared organic excimer electrophosphorescent diodes, *Applied Physics Letters*, 2007, **90**, 023506.
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